(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 924 793 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
23.06.1999 Bulletin 1999/25

(51) Int Cl.[6]: **H01Q 1/24**, H04B 1/38, H04M 1/02

(21) Application number: **98203306.0**

(22) Date of filing: **30.09.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **22.12.1997 US 995602**

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(54) Radio communications handset antenna arrangements

(57) This invention relates to internal antenna arrangements for radio communications handsets. Internal antenna size and shape represents a constraint on handset miniaturisation if good antenna efficiency and bandwidth characteristics are to be maintained. The use of acoustic enhancing volumes of free space about a handset's speaker unit also constrains further miniaturisation. The present invention provides an internal antenna arrangement which facilities further miniaturisation and which combines antenna volume with the acoustic enhancing volume.

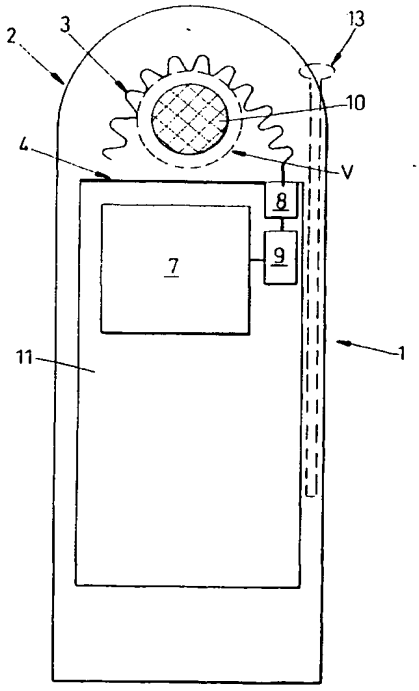

Fig. 1(a)

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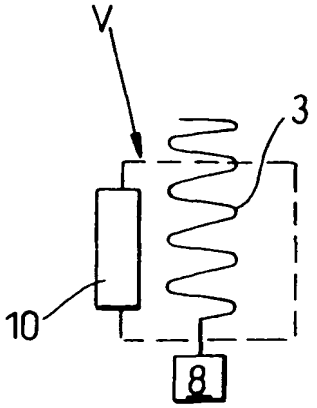


Fig. 1(b)

Description

FIELD OF THE INVENTION

[0001] The invention generally relates to radio communications handsets, and in particular to internal antenna arrangements.

PRIOR ART

[0002] Recent advances in mobile communications have been coupled with increasing demand for miniaturisation of mobile communications handsets. A significant limitation on such miniaturisation is the internal antenna size which cannot easily be reduced.

[0003] Existing antennas used in radio communications handsets include extendible monopoles, microstrip patch antennas, inverted L and F antennas, and helix antennas.

[0004] Half or quarter wavelength monopoles extend a significant length from the handset and have a number of disadvantages including the inconvenience of such a long protuberance which is easily broken and can be hazardous to users eyes for example.

[0005] The microstrip patch , while having a low profile, small size and light weight, has low efficiency or a narrow bandwidth.

[0006] The inverted L antenna requires a significant physical length (quarter wavelength) for efficient operation, this is generally not possible within a handset so that a shortened L is generally inefficient. This can be improved by using a tuning element in the form of a stub to the ground plane giving the antenna an inverted F configuration, however this still suffers from inefficiency and limited bandwidth in the physical size constraints applicable to a handset.

[0007] The helix antenna, while conveniently short, still requires a significant cylindrical volume which may be extended outside the main body of the handset forming a short protuberance. While this facilitates to some extent miniaturisation of the main handset, the protuberance is inconvenient in practical use. The helix also suffers from a narrow bandwidth.

[0008] Various meandering antenna arrangements are also known. US4021810 discloses a 3D array of meander structure conductors above a ground plane which is complex to produce and is susceptible to the vagaries of manufacturing tolerances. WO96/38882 discloses a printed meandering monopole antenna extending from a mobile handset. While the meandering monopole is shorter than a standard monopole, it still represents an inconvenient protuberance outside the handset. WO93/12559 discloses a planar metallic sheet inverted F antenna having dependant elements angled with respect to the planar structure. As such it is delicate and complicated to manufacture.

[0009] In addition to the above mentioned antenna size and volume constraints on the miniaturisation of handsets, there is now an increasing need for a handset to be used in different communications systems such as mobile and cordless telephony or mobiles in different countries, which requires the handset to be operable over more than one frequency band. While a single antenna and a multiple band matching circuit may be employed, this can prove overly complex and costly so that in practice each handset may require a separate antenna for each frequency band together with sufficient spacing between adjacent antennas to minimise coupling effects there between.

OBJECT OF THE INVENTION

[0010] It is an object of the present invention to facilitate handset miniaturisation by providing improved or alternative internal antenna arrangements for such handsets.

SUMMARY OF THE INVENTION

[0011] In accordance with a first aspect of the present invention, there is provided a radio communications handset comprising:

> a speaker having an adjacent volume of free space for acoustic enhancement;
> and an antenna arrangement which incorporates said volume within the antenna arrangement.

[0012] Preferably the antenna arrangement comprises a ground plane and a radiating element, said volume being located between said ground plane and said radiating element. Preferably the radiating element is spaced a non-uniform distance from said ground plane.

[0013] Preferably the antenna arrangement comprises

> a ground plane;
> a meandering radiating element extending in a series of opposing bends from a radio-frequency feed point and spaced a non-uniform distance from said ground plane;
> and wherein said volume is located between said ground plane and said radiating element.

[0014] The opposing bends may be effected in more than one plane.

[0015] Preferably the antenna arrangement further comprises a planar element connected to the free end of said monopole and extending back along and substantially parallel with said monopole.

[0016] The introduction of the planar element allows the second harmonic frequency of the antenna arrangement to be varied; effectively introducing a second controllable resonant frequency band within the single antenna structure.

[0017] Preferably the handset further comprises:

an extendible external antenna;
radio frequency transceiver means; and
antenna switching means which is arranged to switch between said transceiver means and said external antenna or said antenna arrangement upon manual extension or retraction of said external antenna.

[0018] In accordance with a further aspect of the invention, there is provided a radio communications handset comprising an internal antenna arrangement adapted to accommodate one or more handset components, said antenna arrangement comprising:

a ground plane;
a meandering radiating element extending in a series of opposing bends from a radio-frequency feed point and spaced a non-uniform distance from said ground plane;
wherein said handset component is located between said radiating element and said ground plane.

[0019] Preferably the handset component is an acoustic enhancing volume of free space located adjacent a loudspeaker. Alternatively or in addition the component may be another handset part such as an RF filter element located on the periphery of the volume.

[0020] In accordance with a further aspect of the invention, there is provided a radio communications handset internal antenna arrangement comprising:

a ground plane;
a meandering monopole extending in a series of opposing bends from a radio-frequency feed point and spaced a non-uniform distance from said ground plane.

[0021] The ground plane may be formed on the PCB, or an additional metallic plane may be formed perpendicular to the plane of the PCB which extends to a width corresponding to that containing the opposing bends of the meandering monopole.

[0022] Preferably the antenna arrangement further comprises a planar element connected to the free end of said monopole and extending back along and substantially parallel with said monopole.

[0023] The bends may be effected in more than one plane.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] In order that a greater understanding of the invention be obtained, embodiments of the invention will now be described with reference to the accompanying drawings, by way of example only and without intending to be limited, in which:

Figure 1(a) shows a preferred embodiment handset arrangement of the invention, and figure 1(b) shows a detail section of the handset's acoustic volume contained within the handset's antenna arrangement;
Figures 2 (a) and (b) show in detail an preferred embodiment antenna arrangement of the invention in plan and elevation respectively;
Figures 3 (a) and (b) show an alternative embodiment antenna arrangement in perspective and section respectively;
Figures 4 (a) and (b) show a multi band embodiment of the antenna arrangement in plan and elevation respectively;
Figure 5 shows insertion loss for a single band antenna;
Figure 6 shows insertion loss for a dual band antenna;
Figure 7 shows the azimuth radiation pattern for the single band antenna;
Figure 8 shows the azimuth radiation pattern for the dual band antenna; and
Figure 9 shows an external antenna switching arrangement.

DETAILED DESCRIPTION

[0025] Referring to figure 1(a), a handset 1 of the invention is there shown comprising a speaker unit 10 and an adjacent volume of free space V extending behind the speaker unit (as shown in detail 1(b)) for acoustic enhancement: an antenna arrangement 2 comprising a ground plane 4 and a radiating element 3 extending from a radio frequency feed point 8 on the handsets printed circuit board (PCB) 11.

[0026] The radiating element 3 is curved with respect to the ground plane 4 and is arranged to fit around the peripheral edges of the acoustic enhancing volume of free space V, thereby incorporating the volume V within the antenna arrangement 2..

[0027] The ground plane may be formed on the handset's PCB 11, or a metallic plane may be formed perpendicular to the PCB 11 for example by a shielding case.

[0028] The radiating element 3 of the antenna arrangement 2 is preferably a monopole type structure formed into a zig-zag pattern which consists of a series of opposing bends. The zigzag formation of the radiating element 3 maintains a small and convenient volume within the handset 1 while providing a self-resonant antenna 2 as described herein below. This particular antenna construction also provides good antenna efficiency and bandwidth characteristics.

[0029] It should be noted that unlike conventional short antennas for handset applications, such as inverted F and folded monopole antennas, the radiating element 3 of the present invention does not require tuning or matching stubs, nor grounding at any point along its

length to achieve the desired resonant frequency from its compact dimensions. By contrast the radiating element of the invention is fed at one end while the other end is left free. This facilitates inclusion of handset elements such as speaker acoustic enhancing volumes between the radiating element 3 and the ground plane 4.

[0030] The inclusion of the acoustics volume V between the radiating element 3 and the ground plane 4 reduces the combined internal antenna and acoustic volumes on further miniaturisation of handsets with this acoustic volume V.

[0031] A preferred antenna arrangement of the invention is described in more detail with reference to figures 2 (a) and (b). The antenna arrangement 2 comprises a radiating element 3 and ground plane 4 connected to the handset's radio frequency transceiver circuitry 7 via a radio frequency feed point 8. The antenna 2 is shown in plan in figure 2a and in elevation in figure 2b. Referring to figure 2a, the radiating element 3 is a monopole structure which extends from the feed point 8 in a series of opposing bends which form a zigzag pattern of substantially parallel sections 6 separated by the bends 5. Referring to figure 2b, the radiating element 3 extends in a curve A with respect to the ground plane 4.

[0032] Each bend 5 introduces an inductive element L_{bn} into the antenna 2 which increases with sharpness (reduced radius r) of the bend 5. Capacitive elements C_{bn} are introduced between adjacent sections 6 which are dependent on the respective parallel lengths l and distances d between adjacent sections. Further capacitive elements C_{gn} are introduced between the radiating element 3 and the ground plane 4, each notional capacitance C_{gn} being dependent on the distance between the ground plane 4 and radiating element 3 at that point.

[0033] The combination of bends 5 and sections 6 can be thought of as a matching network composed of a variable inductor and capacitor in parallel, together with a shunt capacitor to ground. By varying the length l and separation distance d of the sections 6 the capacitance C_b can be varied and by varying the bend 5 distance or radius r, the inductance L_6 can be varied. Similarly by varying the separation between the radiating element 3 and ground plane 4 and the radiating element radius R, the shunt capacitance C_g can be varied.

[0034] By varying these capacitive and inductive elements experimentally the antenna 2 can be made self-resonant at a desired frequency. The antenna 2 of the invention therefore does not require a matching network for tuning.

[0035] The bandwidth of the antenna can be broadened by extending the total length of the radiating element 3. The capacitive elements C_{gn} also influence the bandwidth of the tuned antenna 2.

[0036] The centre frequency of the antenna 2 is influenced by the capacitive elements C_{gn} and C_{bn} and the inductive elements L_{bn}. In practice these elements are varied experimentally to obtain the desired centre frequency and bandwidth of the antenna 2. The dimensions of the resulting antenna structure can then be mass produced as required.

[0037] Preferably the radiating element 3 consists of a piece of plated wire bent into a series of bends to cause inductance and capacitance along its length. The whole radiating element 3 sits above the ground plane 4 of a PCB 11 in the handset 1, forming a variable impedance transmission line as the distance between the ground plane 4 and radiating element 3 varies.

[0038] The series of bends 5 and sections 6 which form the radiating element 3 need not form a regular pattern as is shown in the preferred embodiment.

[0039] The zig-zag pattern of the bends 5 and sections 6 is formed in a plane colinear with the direction of extension of the radiating element - denoted by curve A in figure 2b. While this plane is shown in figures 2a and 2b as perpendicular to the PCB 11 plane, the zig-zag pattern may be formed in any plane colinear with curve A. For example figure 1 shows the radiating element 3 formed in a plane parallel with the PCB 11 plane.

[0040] As a further alternative the radiating element zigzag pattern may be formed in more than one plane as is shown in figure 3 in which the pattern extends in two perpendicular planes - one parallel and one perpendicular to the PCB 11 plane.

[0041] A further embodiment antenna 2 is shown in figures 4 (a) and (b) which comprises a dual band antenna 2 in which a plate or planar element 20 is connected to the free end of the radiating element 3 extending back from the connection and substantially parallel with the radiating element 3. The presence of the planar element 20 shifts the second harmonic of the fundamental resonant frequency of the antenna 2 along the frequency spectrum effectively introducing a further controllable frequency band. The planar element 20 shifts the second harmonic down the frequency spectrum depending on for example the planar elements length and distance from the radiating element 3. The dimensions of the planar element 20 and its physical relationship to the radiating element 3 are obtained experimentally for the desired frequency bands. Figure 4 shows the dual band antenna tuned to the 850 MHz and 1920 MHz frequency bands.

[0042] In experimentation, the first preferred embodiment antenna arrangement has been shown to have an antenna efficiency of 75% at 850 MHz. For the second preferred dual band antenna arrangement of figure 4, the antenna efficiency at 850 MHz has been measured at 75%, and at the higher band of 1920 MHz an antenna efficiency of 91% has been achieved. This compares favourably with an antenna efficiency of 71% for a helix antenna at 920 MHz.

[0043] Figure 5 shows the insertion loss of the single frequency antenna. It can be seen that adequate return loss (>10dB) is seen across the band, this can be improved by retuning. Placement of the intended speaker unit 10 inside the antenna 2 produced only a slight change in frequency which is readily retuned.

[0044] Figures 6, 7 and 8 show respectively the insertion loss of the dual band antenna; the azimuth radiation pattern of the single band antenna; the azimuth radiation pattern of the dual band antenna at 850 MHz; and at 1920 MHz.

[0045] Referring now to figures 1 and 9 and a further inventive aspect in which a switching arrangement is used to switch between the internal antenna 2 and an external antenna 13 such as a telescopically extendible monopole. This allows each antenna to be individually optimised without the detrimental influence of the other antenna being in circuit. The need for complex and expensive dual matching circuitry is therefore essentially eliminated. The use of the switching arrangement is not restricted to the particular antenna arrangement of the invention as described above, but could be used with any type of internal and external antenna.

[0046] The switching arrangement is shown in more detail in figure 9 and makes use of the manual engagement or disengagement of the external antenna 13. As the external antenna 13 is pulled out a metallic contact 31 attached at its base engages a flat spring contact 32 which disconnects the internal antenna 2 from the transceiver output 33, and simultaneously connects the external antenna 13 to the transceiver output 33. The reverse occurs when the external antenna 13 is manually pushed back into the handset.

[0047] The switching arrangement could also be modified to operate using external antennas which are folded out or which are physically connected to the handset when required. Various alternative switching arrangements are conceivable by a person skilled in the art, including electronic switching, capacitive coupling, and other mechanical switching means.

Claims

1. A radio communications handset comprising:

   a speaker having an adjacent volume of free space for acoustic enhancement;
   and an antenna arrangement which incorporates said volume within the antenna arrangement.

2. A radio communications handset according to claim 1 wherein the antenna arrangement comprises a ground plane and a radiating element, said volume being located between said ground plane and said radiating element.

3. A radio communications handset according to claim 2 wherein the radiating element is spaced a non-uniform distance from said ground plane.

4. A radio communications handset according to claim 1 wherein the antenna arrangement comprises

   a ground plane;
   a meandering radiating element extending in a series of opposing bends from a radio-frequency feed point and spaced a non-uniform distance from said ground plane;
   and wherein said volume is located between said ground plane and said radiating element.

5. A radio communications handset according to claim 4 wherein the antenna arrangement further comprises a planar element connected to the free end of said monopole and extending back along and substantially parallel with said monopole.

6. A radio communications handset according to claim 4 wherein said bends are effected in more than one plane.

7. A radio communications handset according to claim 1 wherein the handset further comprises:

   an extendible external antenna;
   radio frequency transceiver means; and
   antenna switching means which is arranged to switch between said transceiver means and said external antenna or said antenna arrangement upon manual extension or retraction of said external antenna.

8. A radio communications handset comprising an internal antenna arrangement adapted to accommodate one or more handset components, said antenna arrangement comprising:

   a ground plane;
   a meandering radiating element extending in a series of opposing bends from a radio-frequency feed point and spaced a non-uniform distance from said ground plane;
   wherein said handset component is located between said radiating element and said ground plane.

9. A radio communications handset according to claim 8 wherein said handset component is an acoustic enhancing volume of free space adjacent a loudspeaker.

10. A radio communications handset internal antenna arrangement comprising:

    a ground plane;
    a meandering radiating element extending in a series of opposing bends from an radio-frequency feed point and spaced a non-uniform distance from said ground plane.

11. A radio communications handset internal antenna

arrangement according to claim 10 wherein said non-uniform spacing is such that the radiating element extends in an arc across the ground plane.

12. A radio communications handset internal antenna arrangement comprising:

a groundplane;
a meandering radiating element extending in a series of opposing bends from a radio frequency feed point and spaces a non-uniform distance from said ground plane; and
a planar element connected to the free end of said radiating element and extending back along and substantially parallel with said radiating element.

13. A radio communications handset internal antenna arrangement according to claim 12 wherein said non-uniform spacing is such that the radiating element extends in an arc across the ground plane.

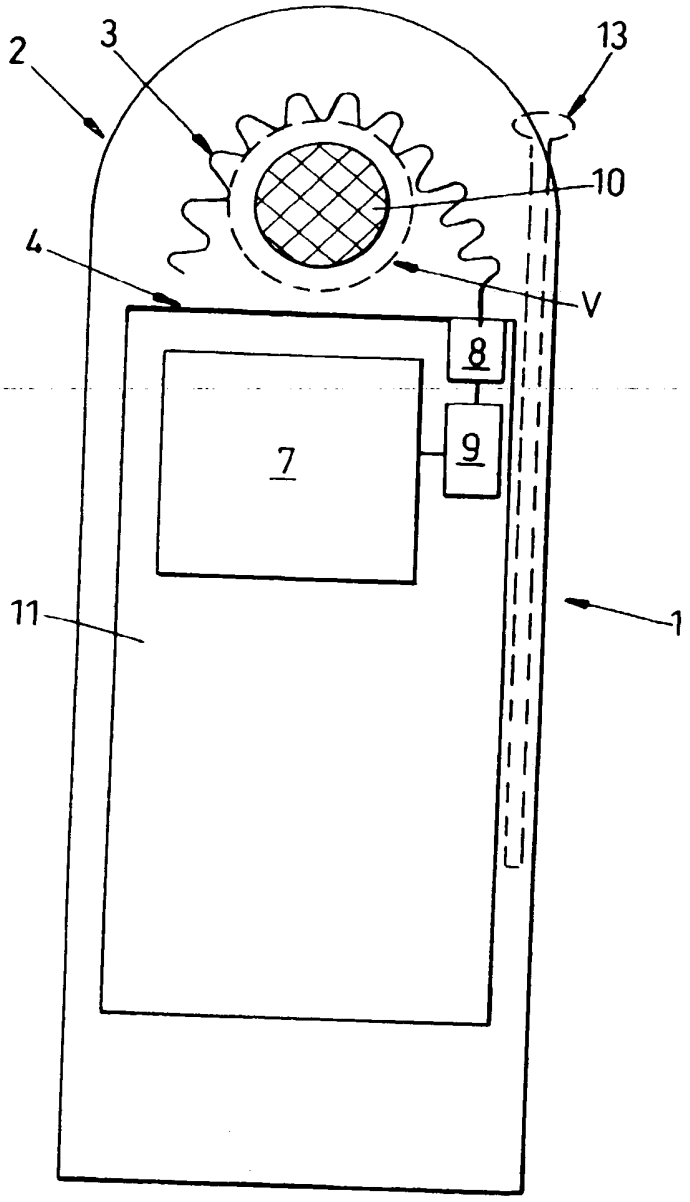


Fig. 1(a)

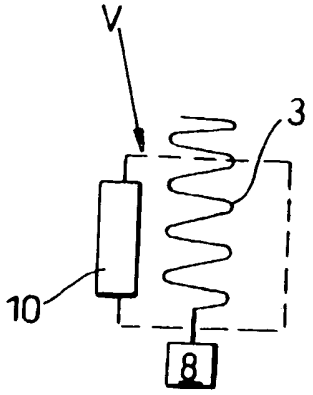


Fig. 1(b)

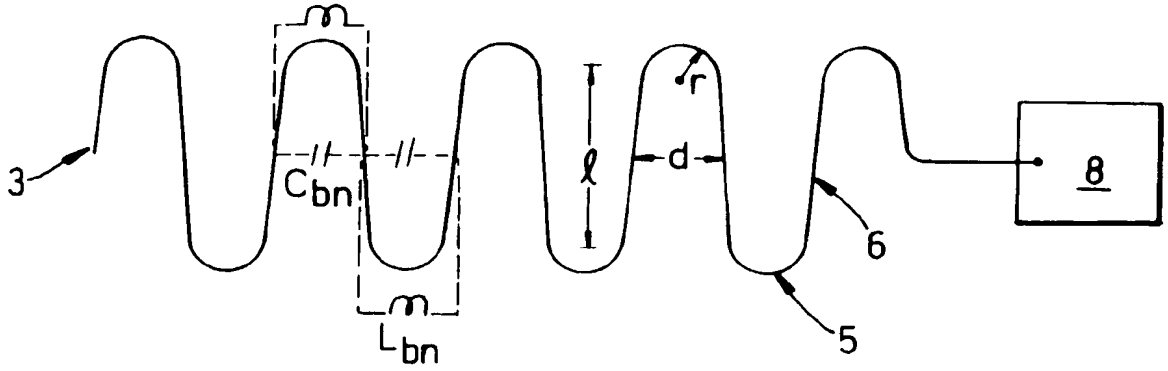


Fig. 2(a)

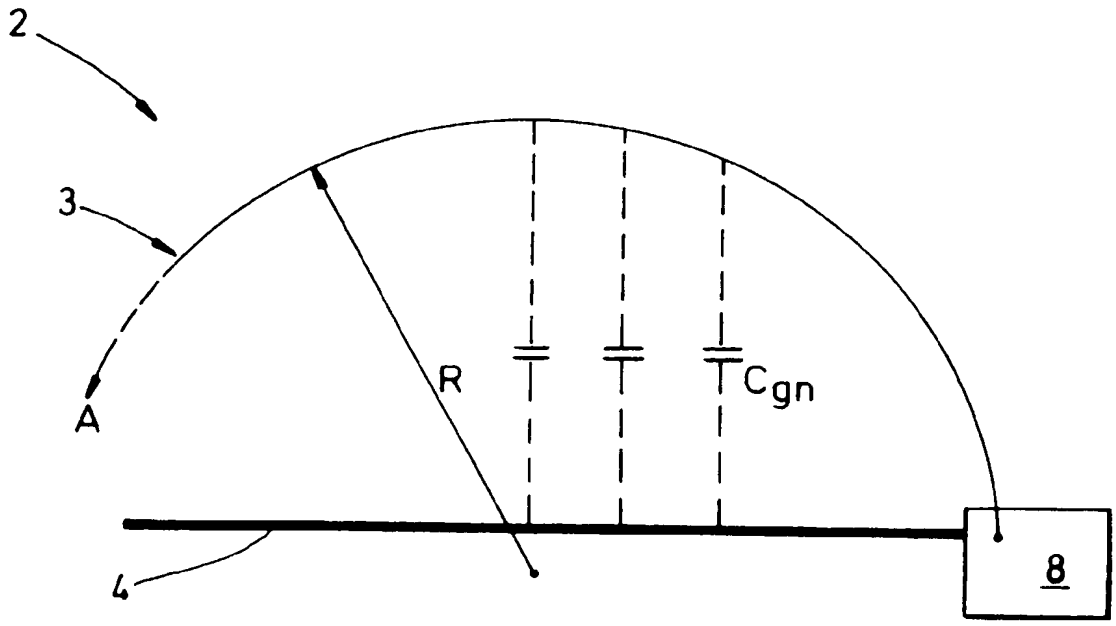


Fig. 2(b)

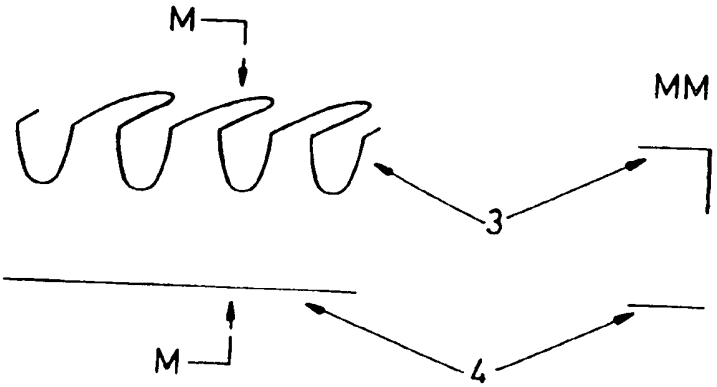


Fig. 3(a) Fig. 3(b)

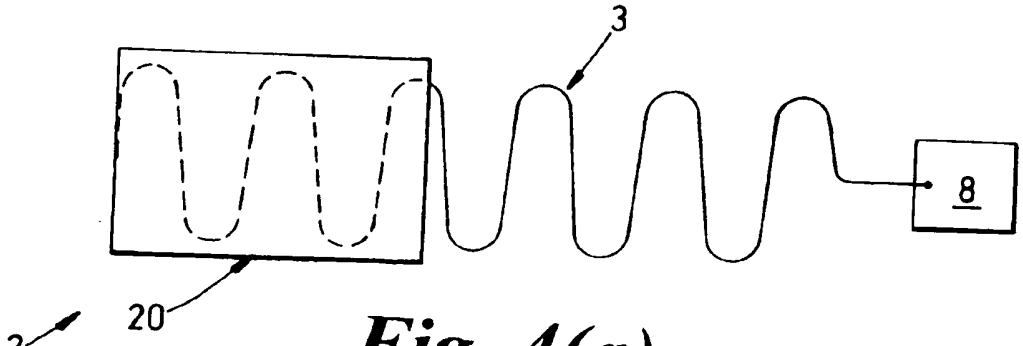


Fig. 4(a)

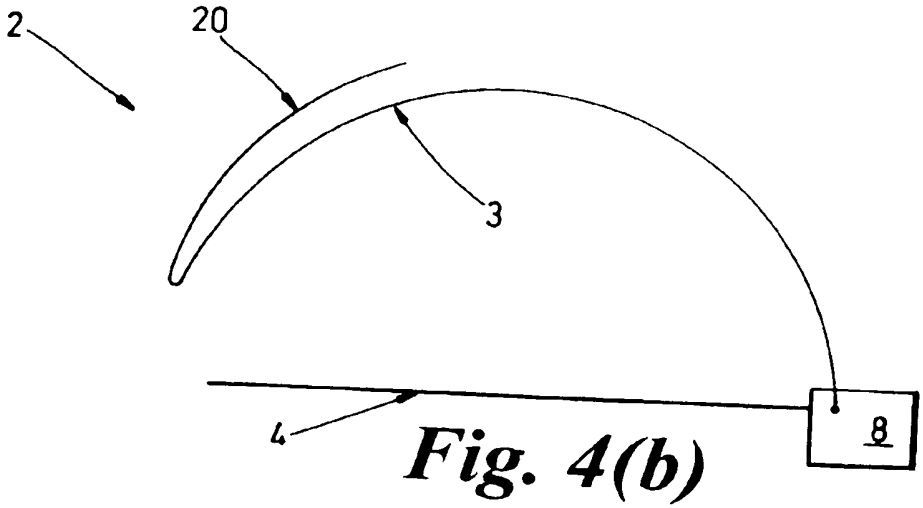


Fig. 4(b)

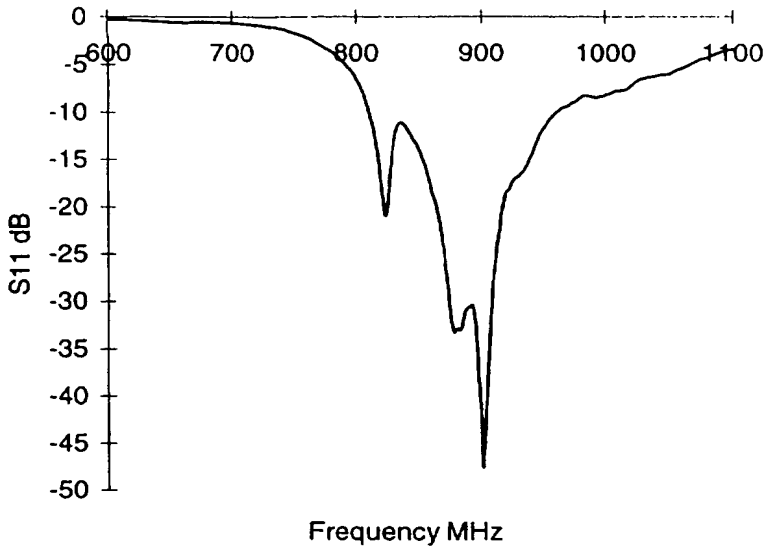


FIGURE 5

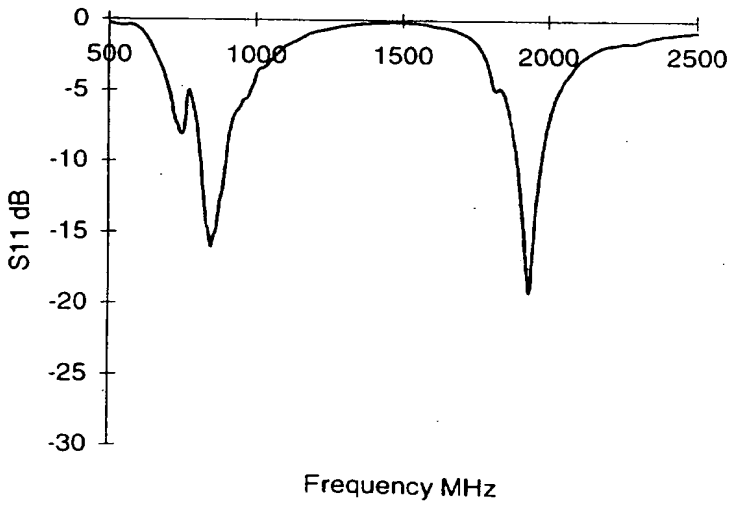


FIGURE 6

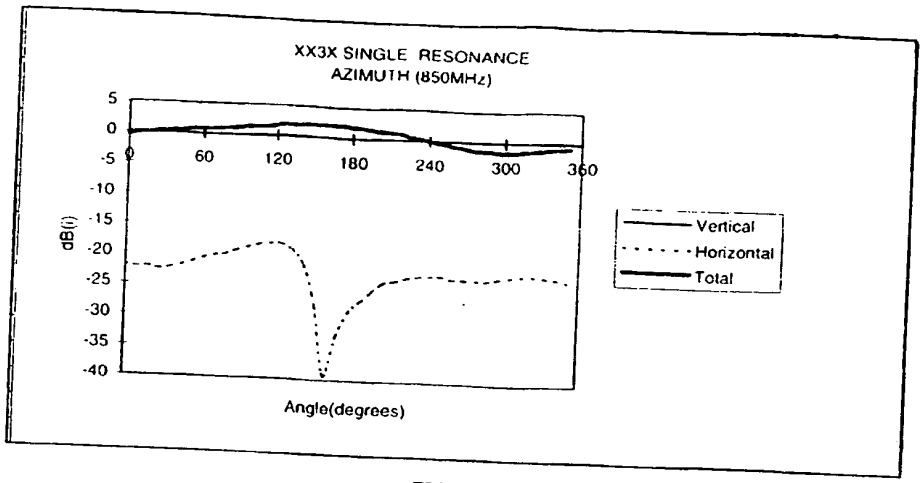
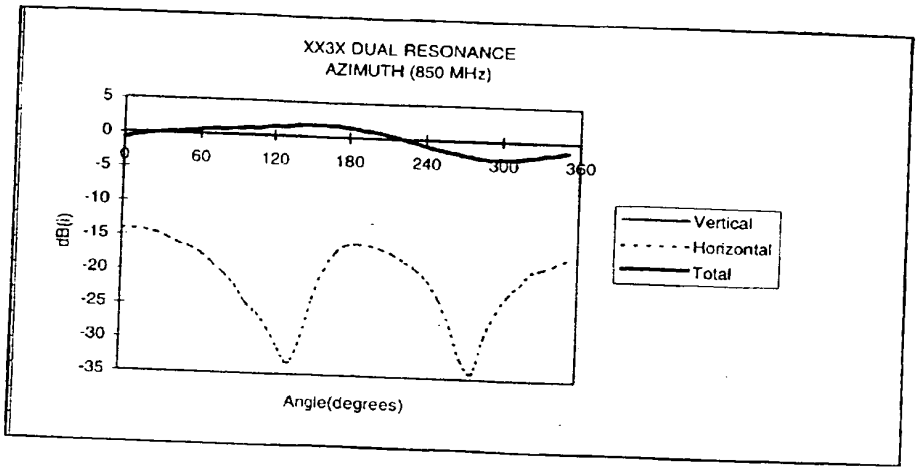


FIGURE 7



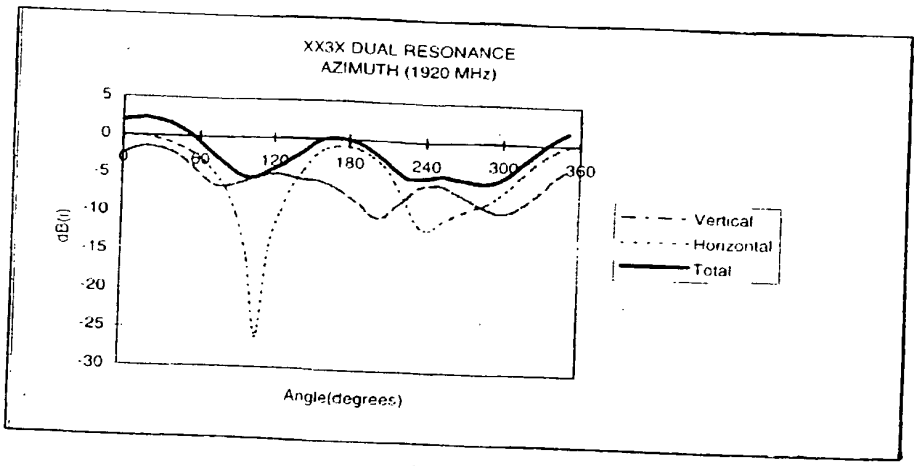


FIGURE 8

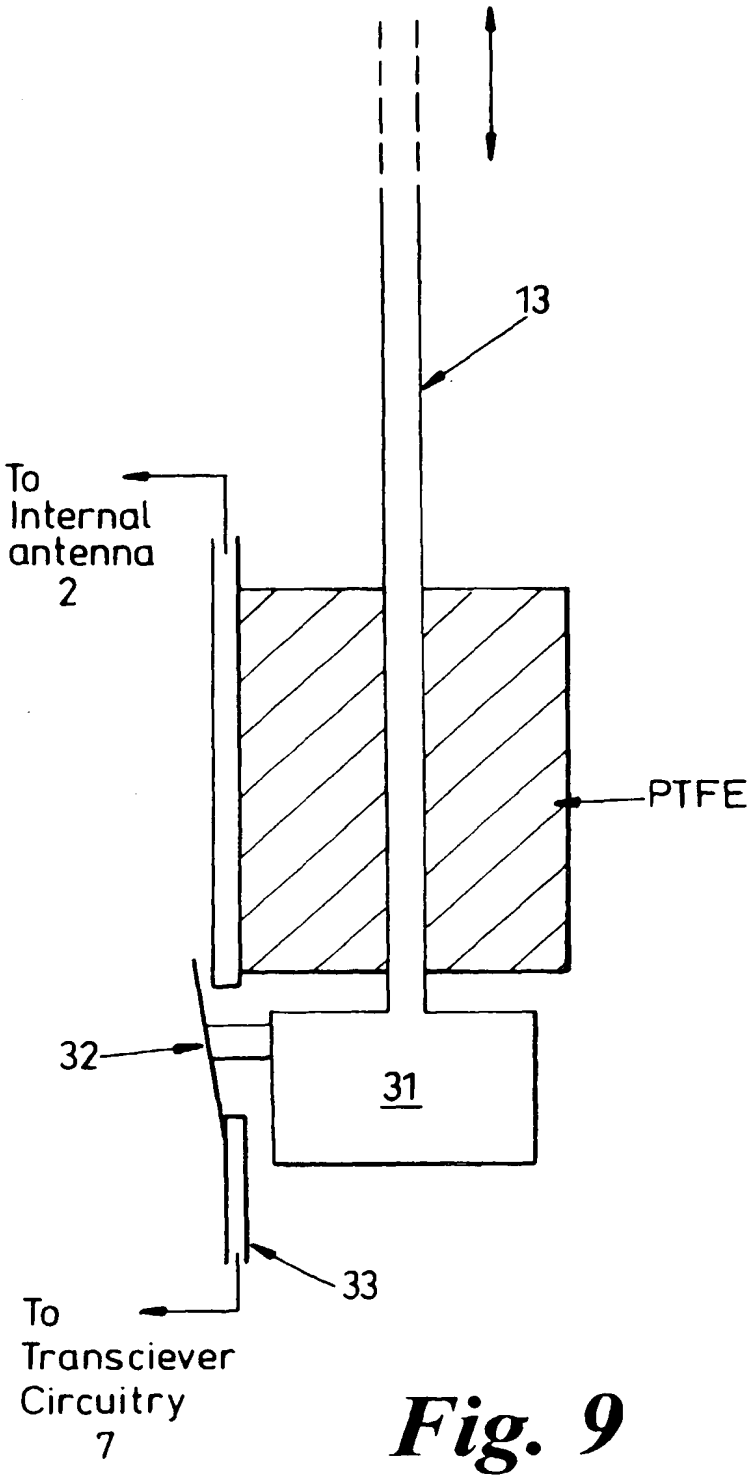


Fig. 9

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 924 793 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
29.03.2000 Bulletin 2000/13

(43) Date of publication A2:
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(21) Application number: **98203306.0**

(22) Date of filing: **30.09.1998**

(51) Int Cl.[7]: **H01Q 1/24**, H04B 1/38, H04M 1/02

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **22.12.1997 US 995602**

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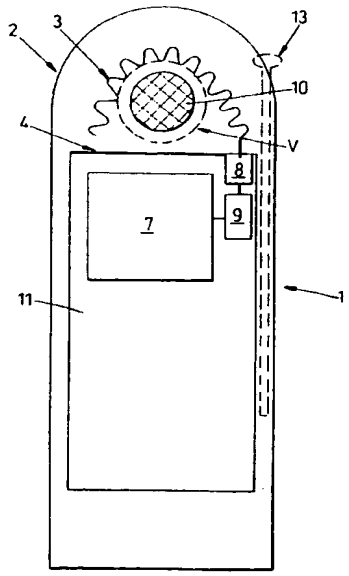

Fig. 1(a)

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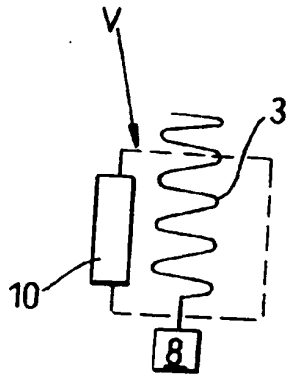

Fig. 1(b)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 20 3306

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 4 679 233 A (RICHARDSON CHARLES P ET AL) 7 July 1987 (1987-07-07) * column 2, line 40 - column 3, line 19; claim 1; figures 2,5 *	1	H01Q1/24 H04B1/38 H04M1/02
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A	DE 44 10 995 A (SAGEM) 6 October 1994 (1994-10-06) * column 2, line 51-66; figure 1 *	1	
A	WO 95 24745 A (CETELCO AS ;PEDERSEN GERT FROELUND (DK); THOMSEN JAN GERT (DK)) 14 September 1995 (1995-09-14) * page 5, line 1-32; figures 1,2 *	1	
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E	EP 0 867 967 A (NOKIA MOBILE PHONES LTD) 30 September 1998 (1998-09-30) * column 6, line 46 - column 7, line 45; figures 2D,5 *	8,10,11	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 August 1999	Van Dooren, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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EPO FORM 1503 03.82 (P04C01)

European Patent Office

Application number
EP 98 20 3306

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 20 3306

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,X	EP 0 851 533 A (NORTHERN TELECOM LTD) 1 July 1998 (1998-07-01) * column 3, line 9-18 * * column 4, line 30-43; claims 1-7; figure 3 *	12,13	
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TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 August 1999	Van Dooren, G

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 98 20 3306

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 1-7

   acoustic enhancing volume in radio communications handset in between internal antenna radiating element and groundplane

2. Claims: 8-13

   radio communications handset with meandering radiating element with non-uniform spacing with regard to groundplane

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 20 3306

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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20-08-1999

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